POLLUTANT TRANSFER THROUGH AIR AND WATER PATHWAYS IN AN URBAN ENVIRONMENT

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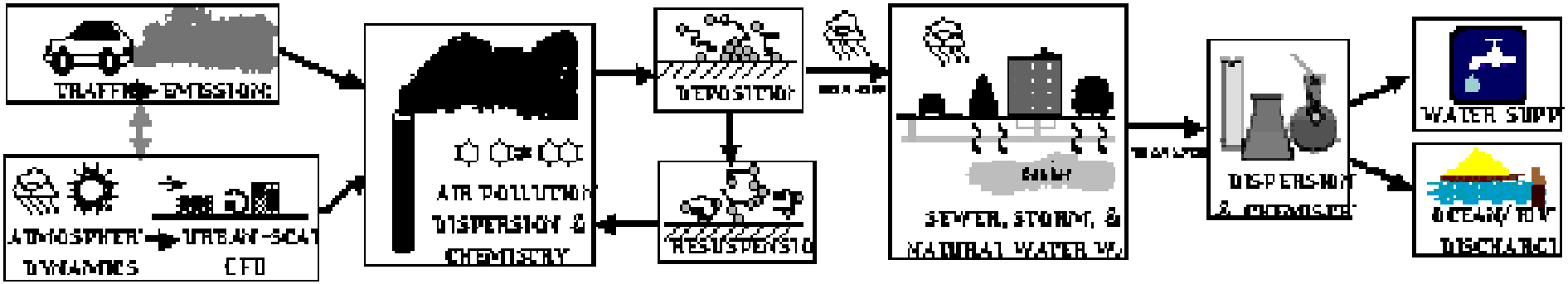
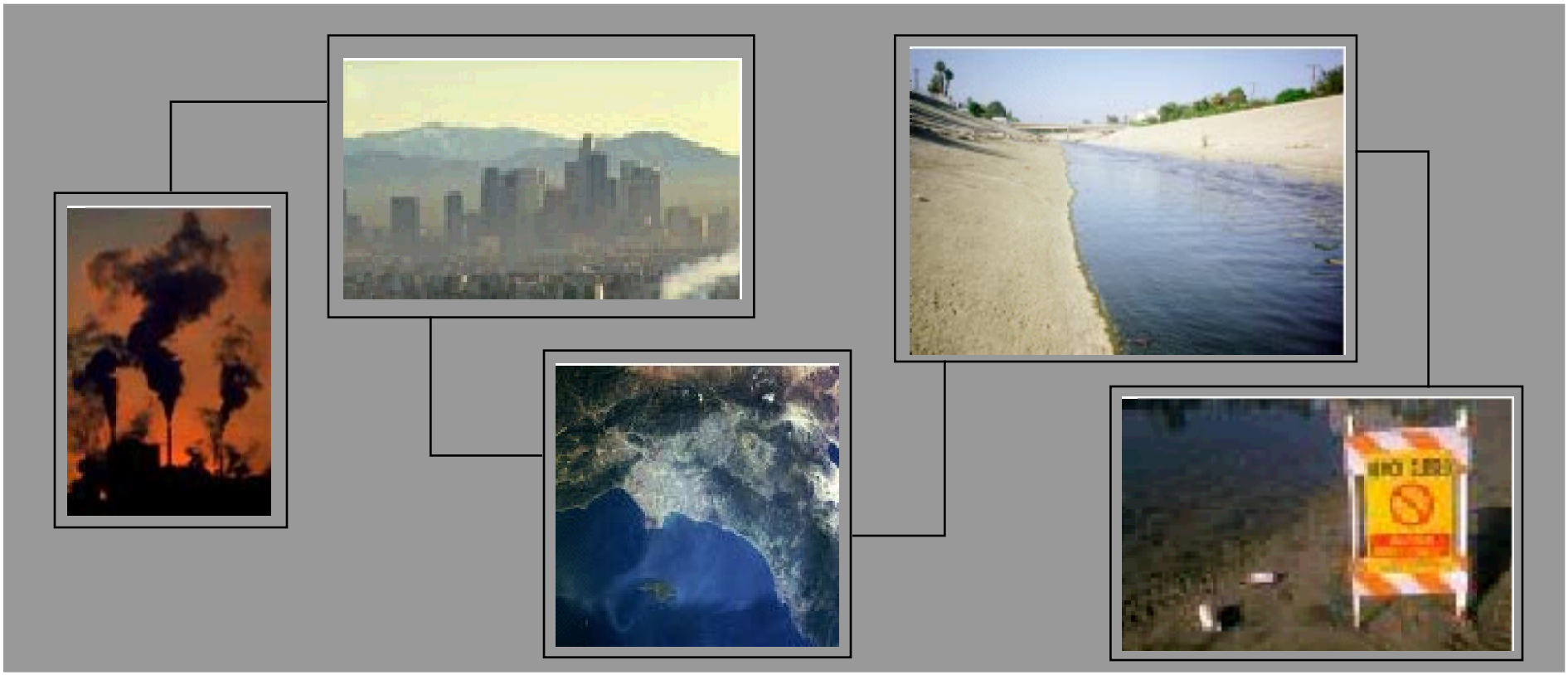
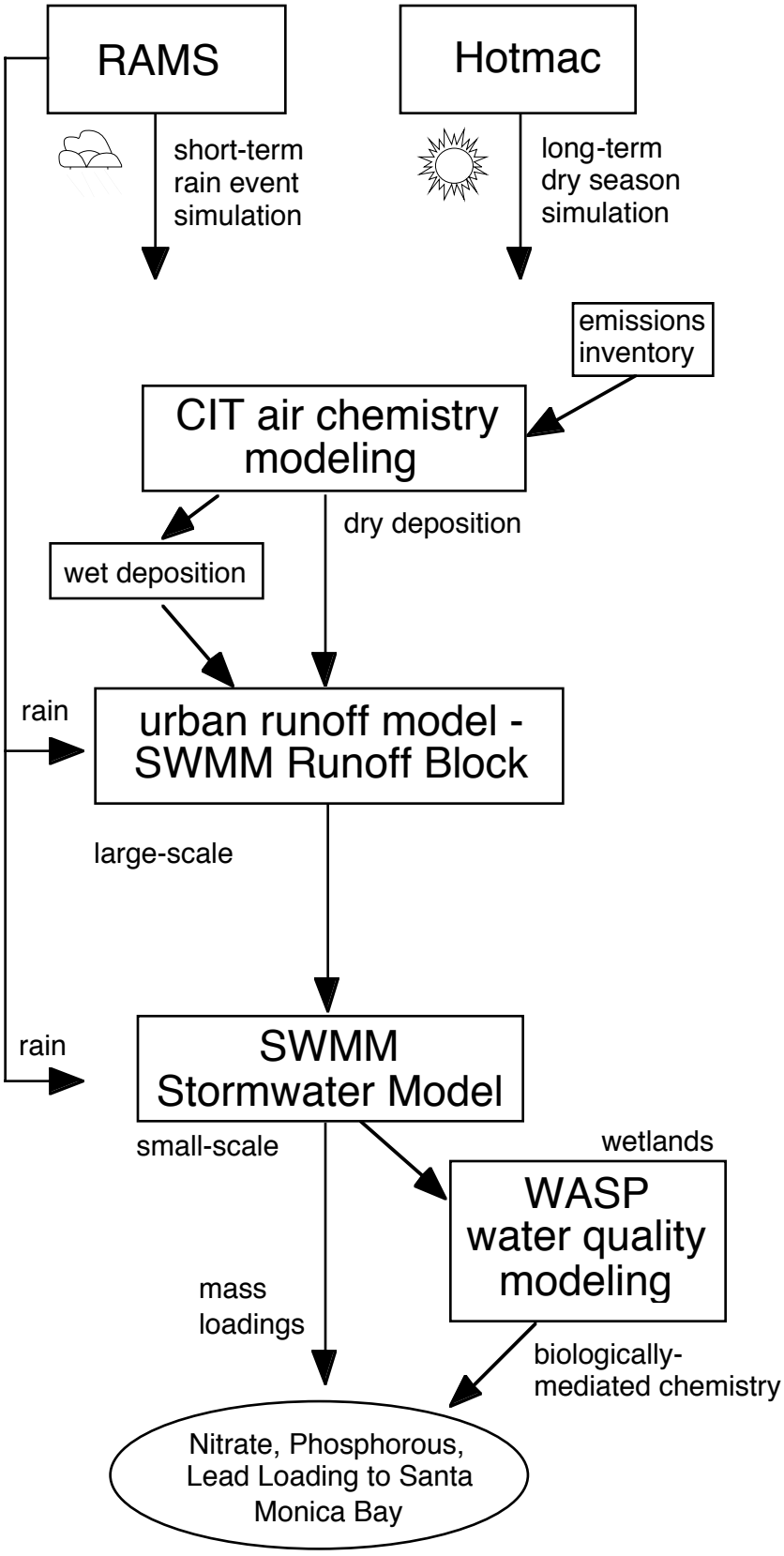
Pollutant Transfer Through Urban Air and Water Pathways





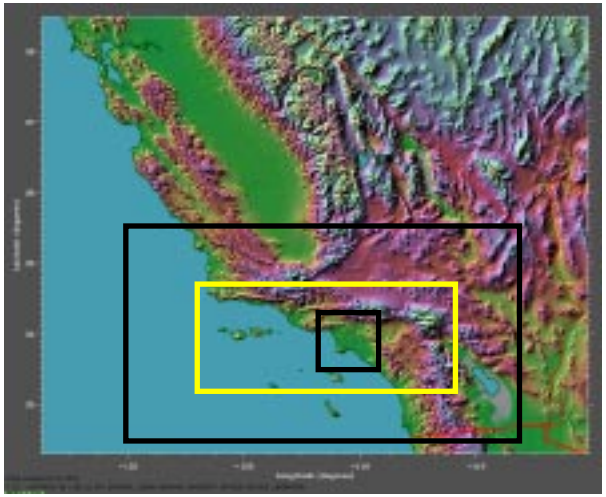
Air-Water Pathways Modeling System



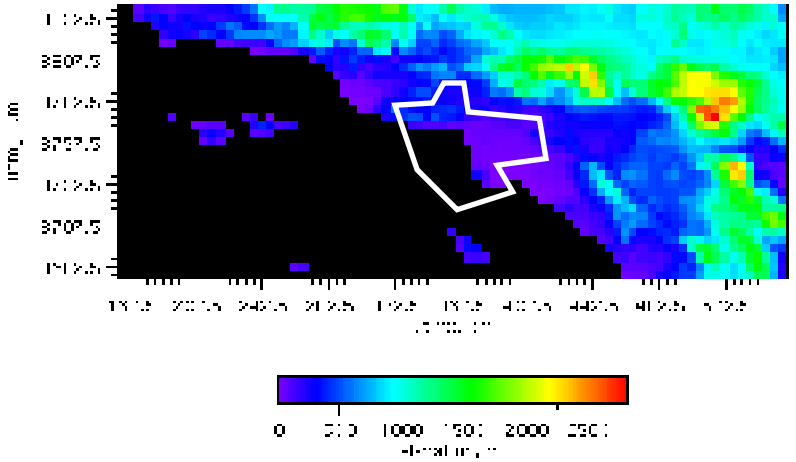
Collaborations

- Georgia Tech. Univ.
- Carnegie Mellon Univ.
- U. Alabama - Civil Eng.
- UCLA School of Public Health
- UCLA Institute of the Environment
- UCLA Civil Engineering
- LA Co. Public Works
- LA City Stormwater Bureau

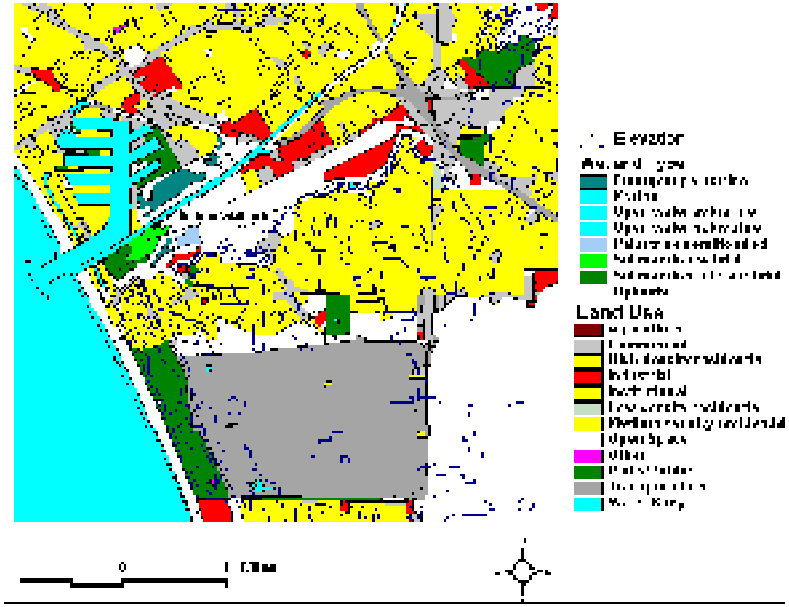
Meteorological Modeling Domain



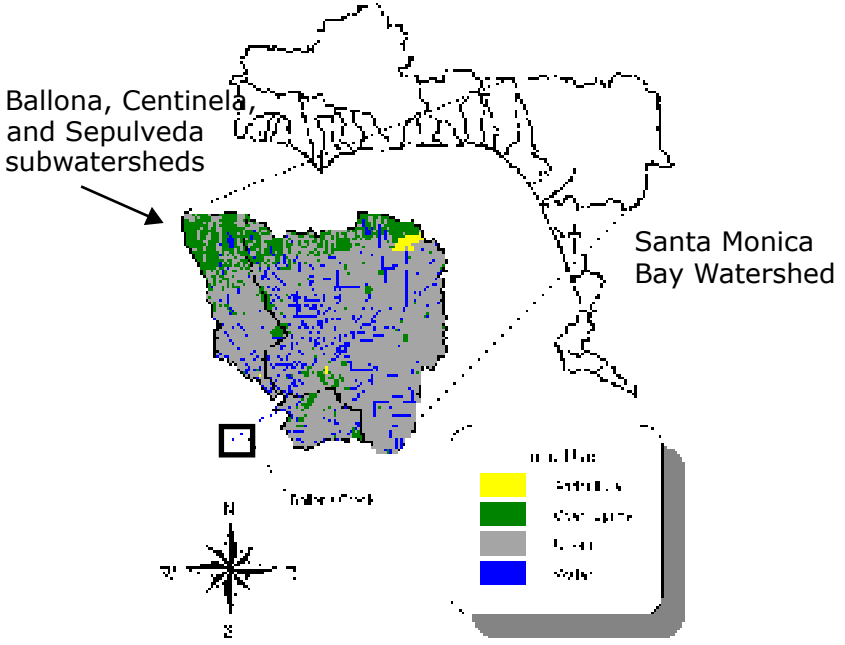
Photochemical Modeling Domain



Wetlands/Water Quality Domain



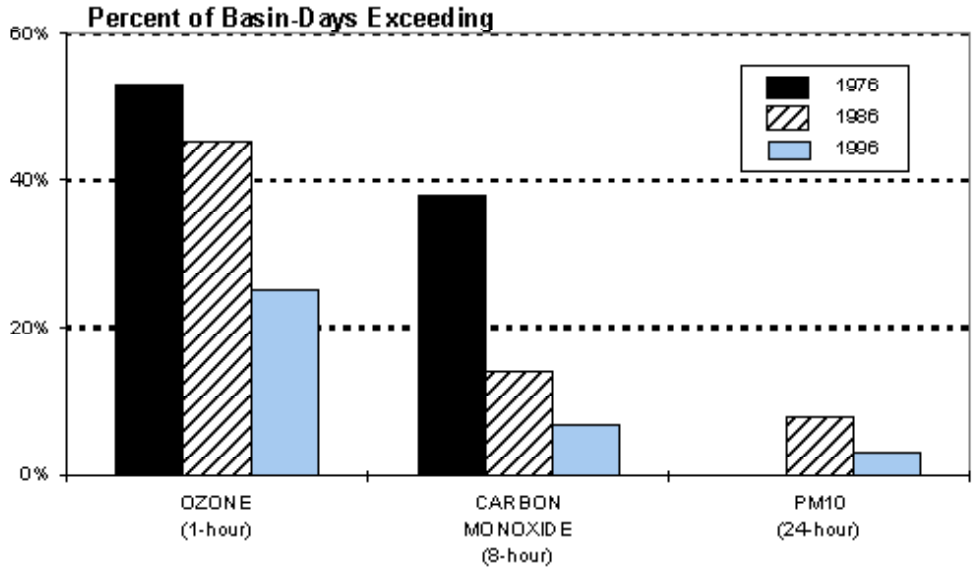
Urban Runoff and Stormwater Modeling Domain



Los Angeles Basin
Air and Water Quality Problems

Air:

Figure 1-a
Percent of Days Exceeding Federal Standard in the Basin
source: South Coast Air Quality Management District



Water:

- Storm water and urban runoff are the most significant uncontrolled sources of pollution to Santa Monica Bay[1].
- The Bay's surfzone exceeds bacterial health risk thresholds each year on average 0.5 - 6.5 % of the time during dry weather and at almost all locations after winter storms[1].
- It is suspected that increases in nitrogen loads are changing the algal population, thereby increasing turbidity and reducing kelp forests[1].

[1]Santa Monica Bay Restoration Project (SMBRP). "Taking the Pulse of the Bay - State of the Bay 1998." Report issued April 1998

RAMS - Regional Atmospheric Modeling System

Capabilities:

- 3-d prognostic mesoscale meteorological code solving non-hydrostatic primitive equations
- terrain-following coordinates, two-way interactive nested grids, vertically-expanding mesh
- vegetation and soil processes at 8 soil levels and surface layer similarity theory
- a partial two moment precipitation microphysics scheme that includes 8 water species

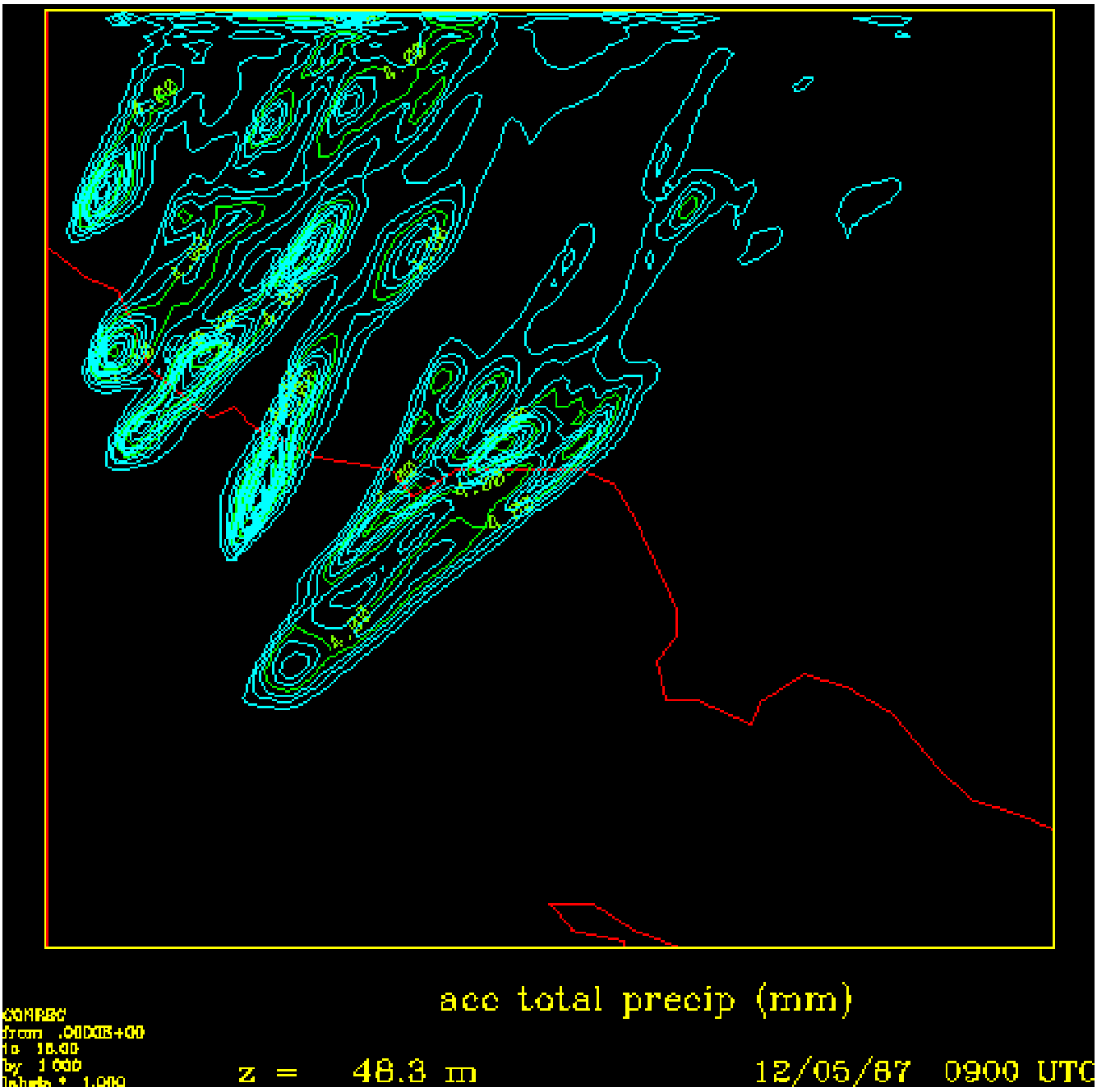
Inputs:

- NCEP 2.5 degree gridded re-analysis data for I.C.'s, B.C.'s and nudging
- topography, land cover, and soil type

Outputs:

- 3-d wind, potential temperature, water mixing ratio, and pressure fields
- time-varying precipitation fields
- short and longwave radiation

RAMS - Precipitation Forecast



HOTMAC - Higher-Order Turbulence Model for Atmospheric Circulation

Capabilities:

- 3-d prognostic atmospheric boundary layer code solving hydrostatic geophysical eqns.
- $1\ ^1/_2$ order q2-l turbulence closure (Mellor-Yamada Level 2.5)
- terrain-following coordinates, multiple nests, vertically-expanding grid
- 2-stream solar radiation approximation, surface energy budget, six soil layers

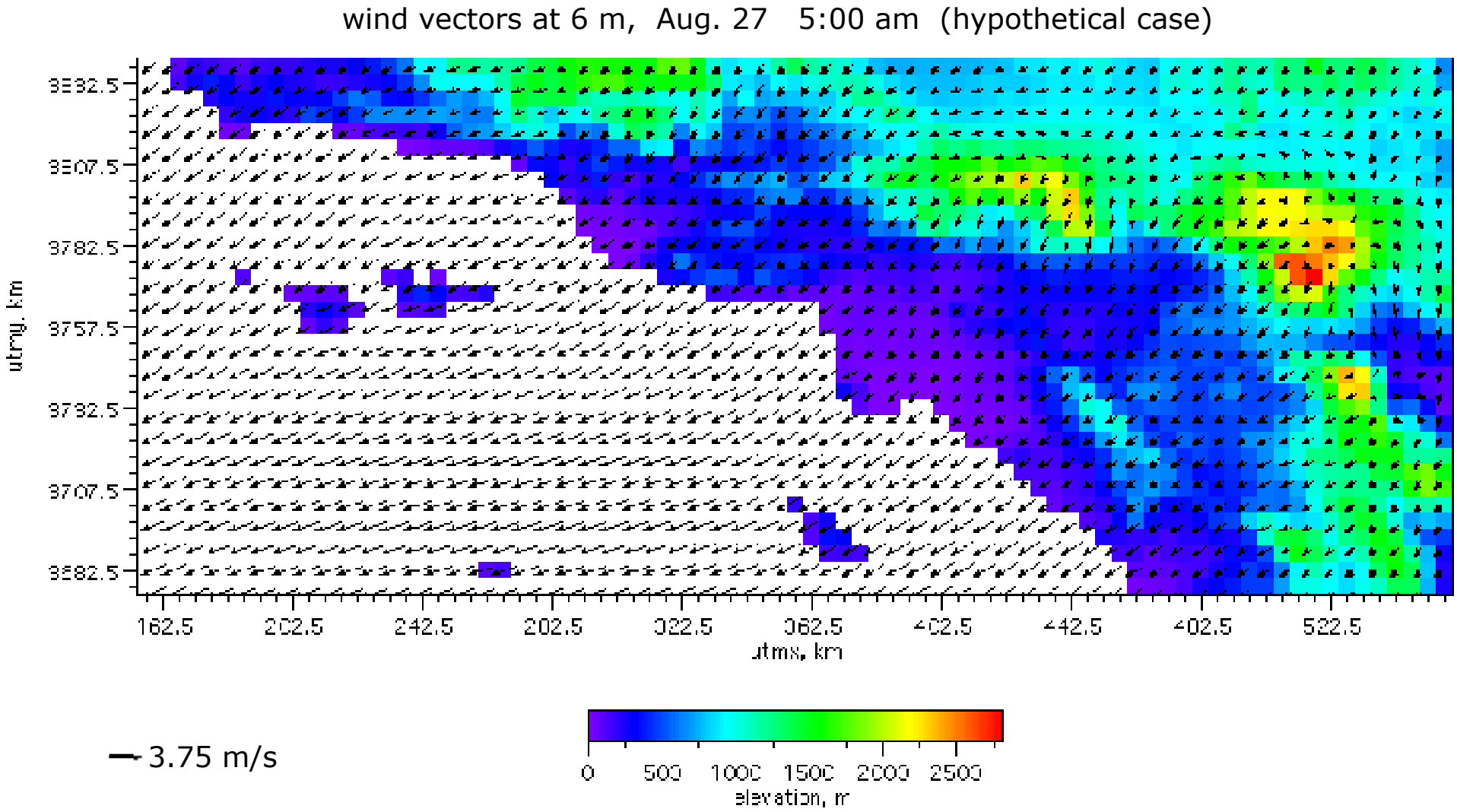
Inputs:

- meteorological I.C.'s and large-scale B.C.'s (minimum of one rawinsonde profile)
- landuse and topography

Outputs:

- mean wind, temperature, and moisture fields
- turbulent kinetic energy and Reynolds shear stress fields
- radiation and heat flux terms

HOTMAC - Wind Field Calculation



CIT - California Institute of Technology Photochemical Model

Capabilities:

- 3-d Eulerian chemistry-transport code
- LCC photochemical mechanism with organics lumped by species
- simple one-component (NH_4NO_3) aerosol model
- gas and aerosol dry deposition using resistance model

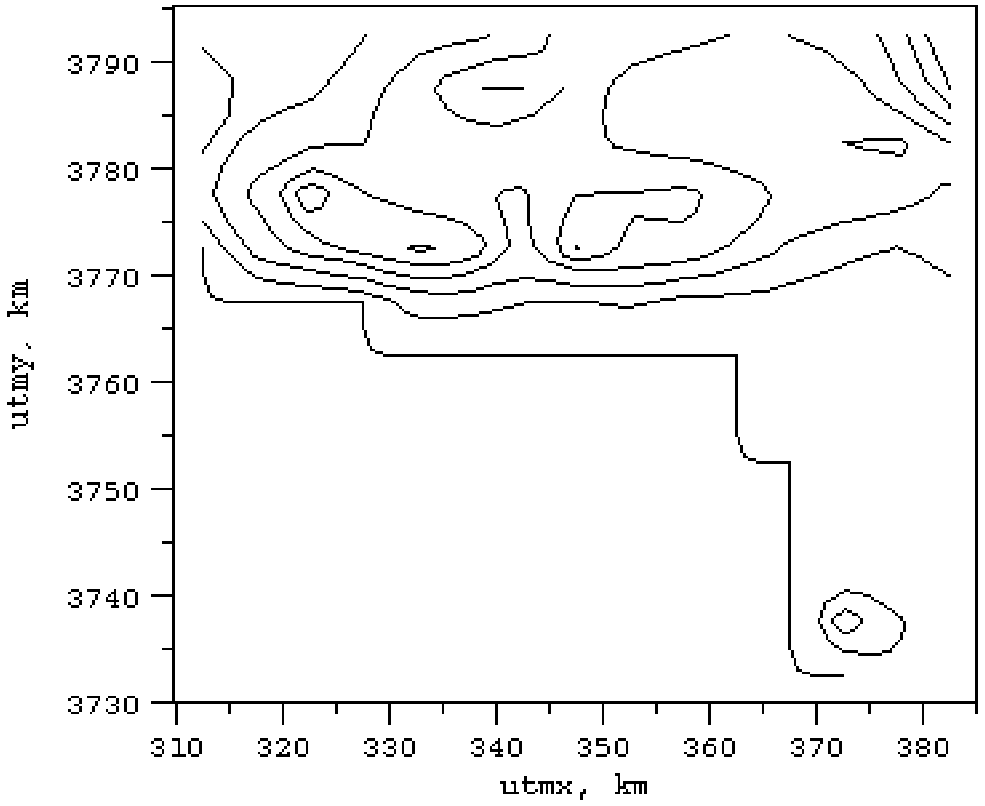
Inputs:

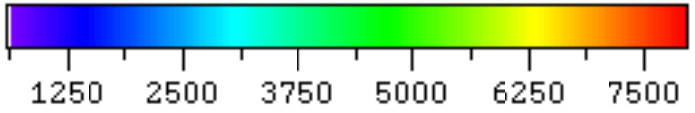
- meteorological fields
- emissions inventory
- land use
- fractional cloud cover (used for solar radiation scaling and stability)
- air quality I.C.'s and B.C.'s

Outputs:

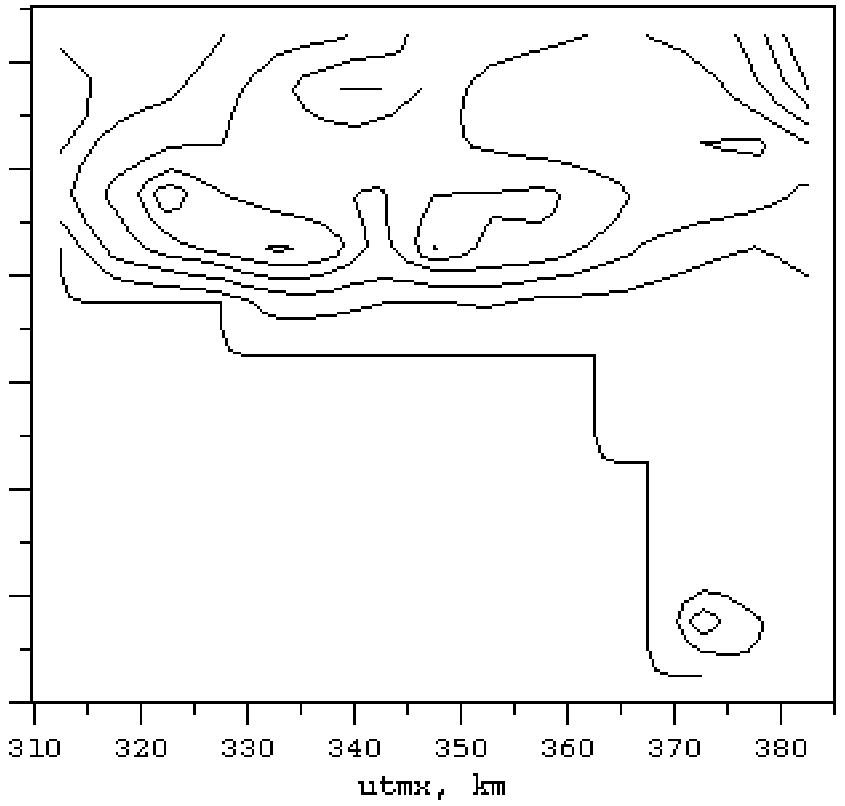
- spatial and temporal concentrations of primary and secondary gaseous pollutants & ammonium nitrate aerosol (NH_4NO_3)
- spatial & temporal fluxes of dry deposition

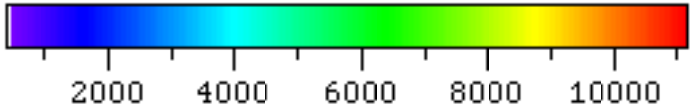
CIT - Nitrogen Deposition Field Predictions





NO_2 deposition, $g/(km^2*day)$





HNO_3 deposition, $g/(km^2*day)$

SWMM - Storm Water Management Model

Capabilities:

- Pollutant build-up/washoff
- Stormwater runoff employing a non-linear reservoir algorithm
- Time-variant flow through the storm drainage system by solving the conservation of mass and momentum partial differential equations (St. Venant equations)
- Surcharge conditions in the drainage system & simple control and treatment systems

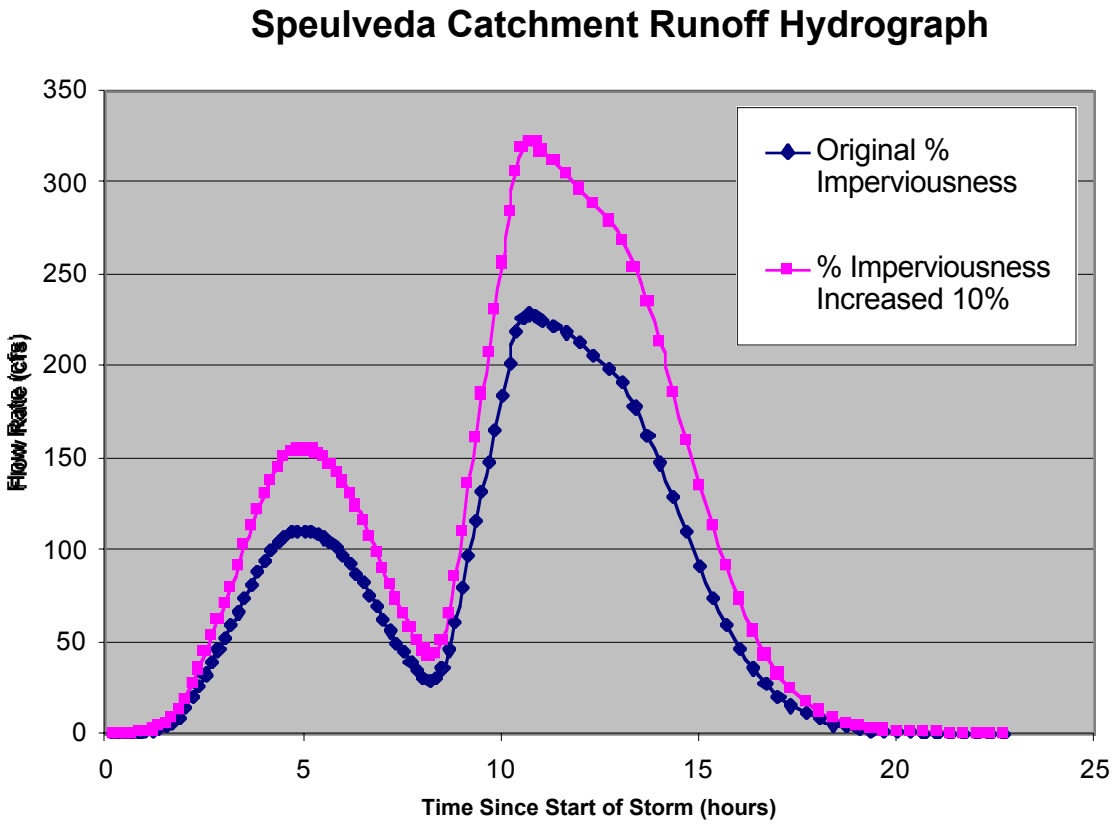
Inputs:

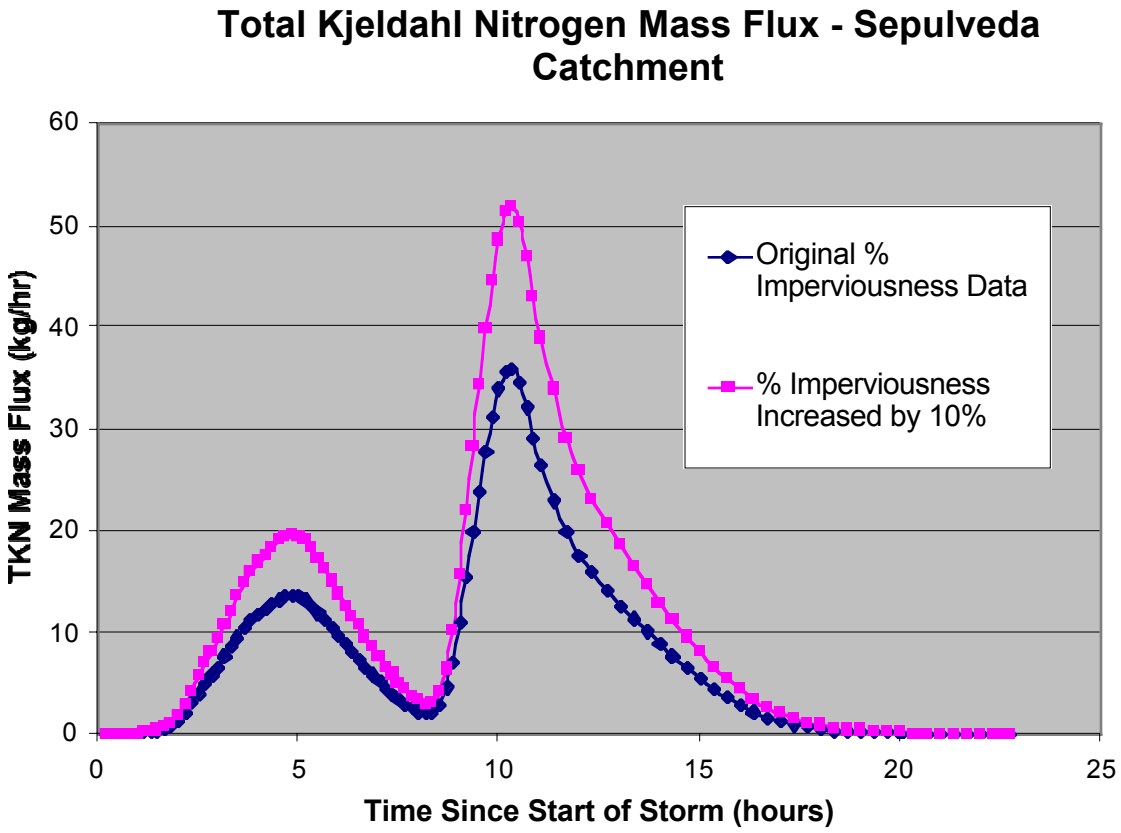
- Precipitation, temperature, and wind
- Urban catchment characteristics (percent imperviousness, land use, slope, area, width)
- Drainage system characteristics (type of conduit, slope, size, length, roughness)
- Pollutant characteristics (parameters for build-up and washoff functions, decay, concentration in precipitation)

Outputs:

- Runoff flow rate and pollutant concentration timeseries at selected points in the urban catchment or drainage system

SWMM - Runoff Calculations





WASP - Water Quality Analysis Simulation Program

Capabilities:

- Predicts dissolved and sorbed chemical concentrations and the effects of nutrients on dissolved oxygen and phytoplankton in 1, 2, or 3 dimensions.
- Accounts for advection, dispersion, settling, resuspension, sedimentation, evaporation, precipitation, photolysis, hydrolysis, and other reactions mechanisms.

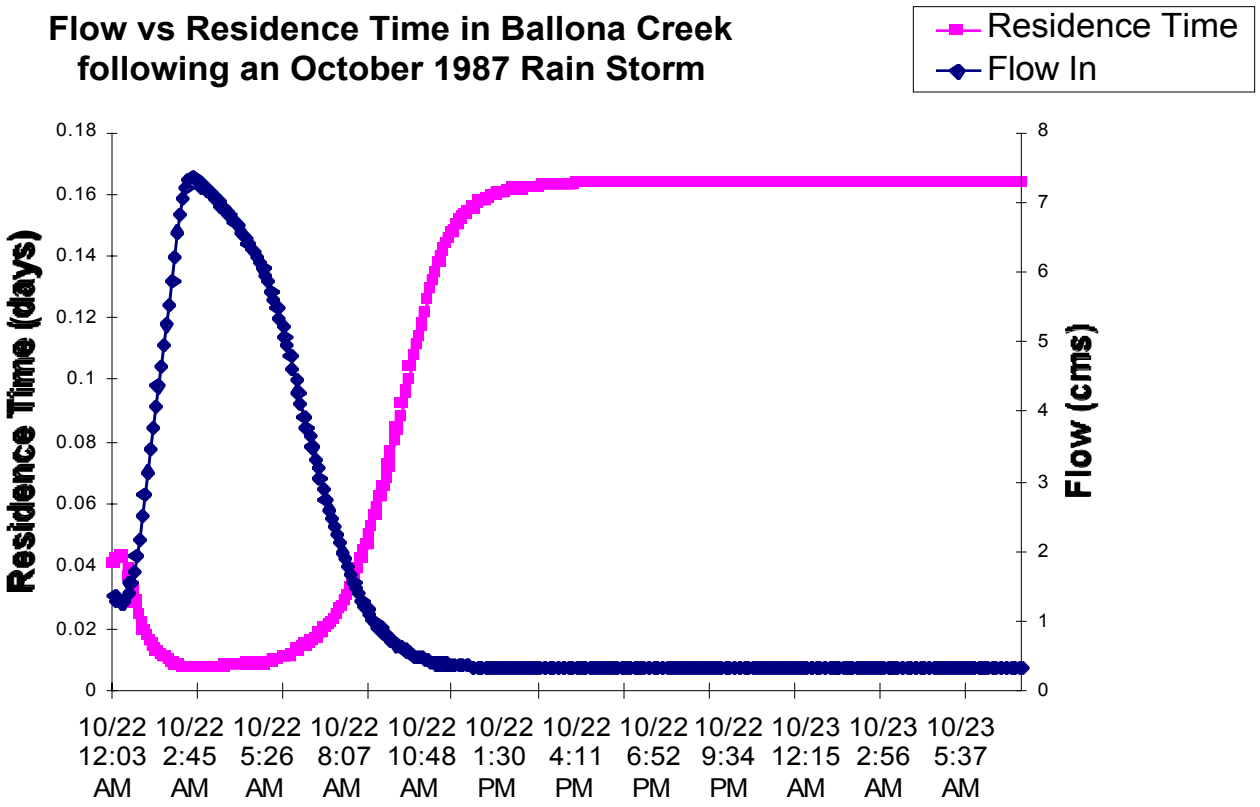
Inputs:

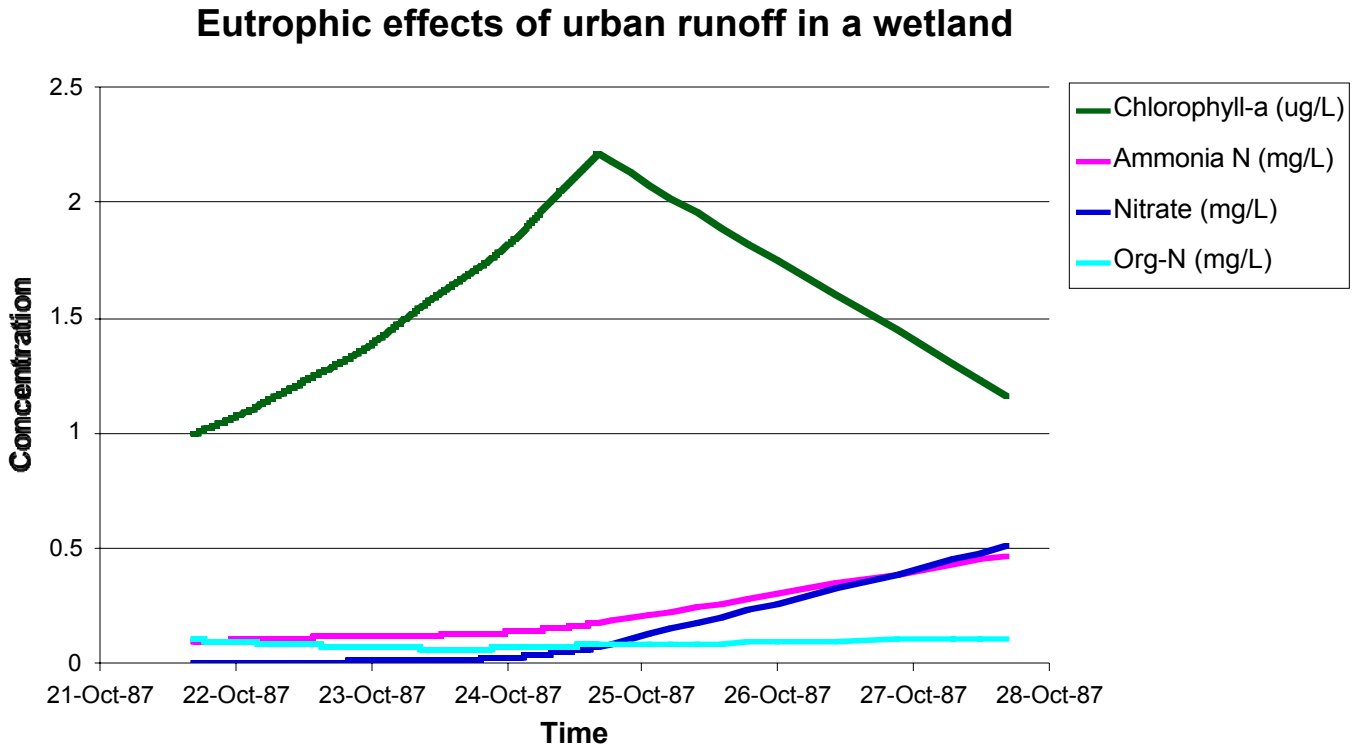
- Hydrodynamics: depth, width, length, velocities, channel orientation, tidal fluctuations, tributary inflows, and wind stress.
- Water Quality: volumes, flows, boundary and initial concentrations, waste loads, and transport and reaction kinetic constants.

Outputs:

- Time series of dissolved and sorbed chemical concentrations

WASP - Flow & Water Quality Computations





Types of Questions We Hope To Answer

- What fraction of nitrogen comes directly from atmospheric deposition vs. urban runoff in coastal water bodies?
- What fraction of nitrogen in urban runoff is due to atmospheric deposition?
- What is the relative contribution of dry and wet atmospheric deposition to surface mass loading?
- What is the effectiveness of wetlands for water purification?
- How do air pollution reduction strategies impact both air and water quality?
- What are the vulnerabilities of the flood-control components of the storm drainage system for different storm events?
- What datasets/measurements are critical for defining, understanding, and managing multimedia urban environmental issues?

Issues

Data!

- input data often not in electronic format
- cross-disciplinary validation data often not available

Interface Processes, e.g.,

- availability of atmospheric deposited nitrogren to urban runoff

Linked Modeling System Uncertainty

- sensitivity to input data and propogation of errors through the model linkages

Model Physics

- clouds and precipitation
- urban canopy parameterizations
- wet aerosol chemistry
- time-variant precipitation scavenging
- storm surge flow dynamics
- biologically-mediated chemistry
- tidal influences